Emissions Technologies for Off-Highway Compression Ignition Engines.

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AVL Powertrain Engineering
Who is AVL?

Largest Independent Powertrain Consulting Company

2400 employees worldwide

Privately owned

Total revenues more than $300m

Based in Graz, Austria

US facility in Plymouth, MI

Business areas:

- Development of powertrain systems
- Instrumentation and test systems
<table>
<thead>
<tr>
<th>Power Range</th>
<th>Test Cycle</th>
<th>NOx Limit</th>
<th>PM Limit</th>
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<tbody>
<tr>
<td>75 kW &lt; 130</td>
<td>(NOx) 9.2/--</td>
<td>6.6/0.3</td>
<td></td>
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<tr>
<td>130 kW &lt; 225</td>
<td>(NOx) 9.2/0.54</td>
<td>6.6/0.2</td>
<td>4.0/0.2</td>
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<tr>
<td>225 kW &lt; 450</td>
<td>(NOx) 9.2/0.54</td>
<td>6.4/0.2</td>
<td>4.0/0.2</td>
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Test cycle and particulate limit to be reviewed by the EPA in 2001.
AVL considers the following technologies to be feasible options for Tier 3 non-road emissions control:

- Cooled Exhaust Gas Recirculation
- Advanced fuel system technology
- Improved diesel fuel
- Exhaust aftertreatment
Bypass Flow Venturi Concept:

Characteristics:

- Venturi used to aid flow of exhaust gas to the intake manifold
- EGR rates of 6-8% at intermediate speed
- Moderate EGR rates at rated speed
- Moderate to high heat rejection rate

Applications:

- Applications requiring good fuel economy
- Engines with little or no injection rate control or aftertreatment
**Unit pump and Unit injector systems are the preferred cam driven types:**

- **Higher maximum injection pressure and favorable pressure characteristics**
- **Capable of pilot injection and “boot” injection**
Both systems will have similar capabilities:

- **Hydraulic intensifier system** may prove advantageous if hydraulic power from the pump can be used with other vehicle systems. New digital valve types can provide pilot injection.

- **High pressure common rail system** could share high volume with passenger car types, reducing cost.
Electronic control provides many advantages at Tier 3 emissions levels:

- Reduced soot in oil for engines
- Improved cold starting
- Rating flexibility
- Reduced combustion noise
Particulate reduction:

• Reduced sulfur content provides a direct reduction in particulates due to reduced sulfates in the particulate matter.
For off-highway diesel engines, fuel sulfur level will be critical if aftertreatment is employed:

Particulate reduction:

- CRT (Continuously regenerating trap) - Requires fuel Sulfur levels below 50 ppm
- Oxidation catalyst - Requires fuel Sulfur levels below 500 ppm

NOx Reduction:

- De-NOx catalysts using diesel fuel post-injection require fuel Sulfur levels below 10 ppm
- SCR (Selective Catalytic Reduction) - Requires a separate onboard supply of reducing agent.
- OBD is required to indicate lack of additive and to control trap loading.
- Low Sulfur fuel is not required with SCR
Durability connects emissions reductions that are possible to emissions reductions that are practical. The main durability issues for Tier 3 are:

- EGR control component durability
- Turbocharger durability
- Soot loading in the lube oil
- Aftertreatment device durability